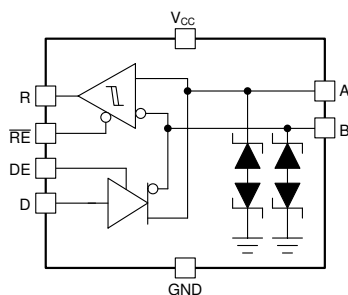


# THVD24x9 3V to 5.5V RS-485 Transceivers With Integrated Surge and High Bus-Fault Protection in Small Packages

## 1 Features

- Meets or exceeds the requirements of the TIA/EIA-485A standard
- 3V to 5.5V Supply Voltage
- Industry's smallest surge-integrated RS-485 device in 9mm<sup>2</sup> package
- V<sub>IO</sub> Support from 1.65V to V<sub>CC</sub> supply level
- Bus I/O protection
  - ±3kV/42Ω IEC 61000-4-5 1.2/50μs surge (SOIC)
  - ±1.5kV/42Ω IEC 61000-4-5 1.2/50μs surge (VSON)
  - ±8kV IEC 61000-4-2 Contact discharge
  - ±4kV IEC 61000-4-4 Electrical fast transient
  - ±15kV HBM ESD
  - ±42V DC bus fault
- Available in two speed grades
  - THVD2419: 250kbps
  - THVD2429: 20Mbps
- Extended ambient temperature range: -40°C to 125°C
- Extended operational common-mode range: ±25V
- Large receiver hysteresis for noise rejection
- Low power consumption in shutdown mode: < 5μA
- Glitch-free power-up and down for hot plug-in capability
- Open, short, and idle bus failsafe
- 1/8 Unit load (up to 256 bus nodes)
- Industry standard 8-pin SOIC for drop-in compatibility
- Small surge-integrated RS-485 device in 3mm x 3mm leadless (VSON) package



THVD24x9 Block Diagram (SOIC Package)

## 2 Applications

- [Wireless infrastructure](#)
- [Factory automation](#)
- [Motor drives](#)
- [Building automation](#)
- [HVAC](#)
- [Grid infrastructure](#)

## 3 Description

THVD24x9 devices are half-duplex RS-485 transceivers with integrated surge protection. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package as well as small 10-pin VSON package. This feature increases the reliability by providing better immunity to noise transients coupled to the data cable which eliminates the need for external protection components.

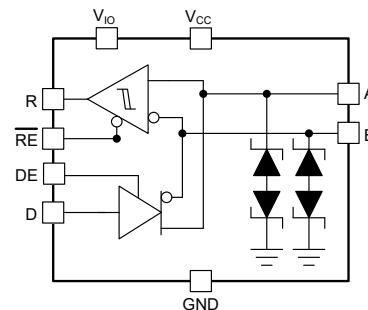
THVD24x9 devices in the standard pin-out SOIC package operate from a single 3.3V or 5V supply. In addition, THVD24x9 devices in 10-pin VSON package support an additional V<sub>IO</sub> supply to operate the IOs from as low as 1.65V supply level. The devices in this family feature a wide common-mode voltage range making them suitable for multi-point applications over long cable runs.

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
THVD2419	SOIC (8)	4.9mm × 6mm
THVD2429	VSON (10)	3mm × 3mm

(1) For more information, see [Section 12](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



THVD24x9 Block Diagram (VSON Package)

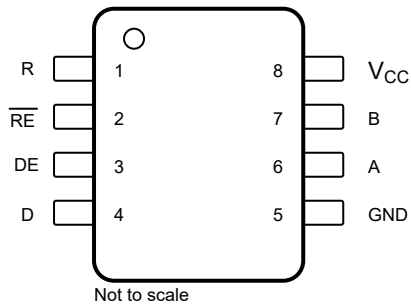
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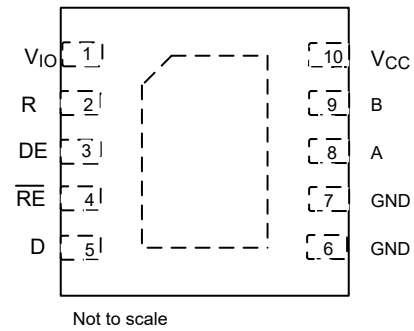
## 4 Device Comparison Table

PART NUMBER	PACKAGE	V <sub>IO</sub>	SIGNALING RATE	NODES
THVD2419	SOIC-8	No	up to 250kbps	256
THVD2429			up to 20Mbps	
THVD2419	VSON-10	Yes	up to 250kbps	
THVD2429			up to 20Mbps	

## 5 Pin Configuration and Functions



**Figure 5-1. THVD2419, THVD2429, 8-Pin (SOIC)  
(Top View)**



**Figure 5-2. THVD2419, THVD2429, 10-Pin (VSON)  
(Top View)**

NAME	PIN		TYPE	DESCRIPTION
	SOIC-8	VSON-10		
V <sub>IO</sub>	-	1	P	1.8V to 5V supply for R, D, and $\overline{RE}$ and DE
R	1	2	O	Receiver data output
$\overline{RE}$	2	4	I	Receiver enable, active low (integrated pull-up)
DE	3	3	I	Driver enable, active high (integrated pull-down)
D	4	5	I	Driver data input (integrated pull-up)
GND	5	6, 7	-	Device ground
A	6	8	I/O	Bus I/O port, A (complementary to B)
B	7	9	I/O	Bus I/O port, B (complementary to A)
V <sub>CC</sub>	8	10	P	3.3V to 5V supply for the device

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
Logic supply voltage	$V_{IO}$	-0.5	$V_{CC} + 0.2$	V
Bus supply voltage	$V_{CC}$	-0.5	6.5	V
Bus voltage	Range at any bus pin (A or B) as differential or common-mode with respect to GND	-42	42	V
Input voltage	Range at any logic pin (D, DE, SLR or $\overline{RE}$ ) for devices with VIO pin	-0.3	$V_{IO} + 0.2$	V
Input voltage	Range at any logic pin (D, DE, SLR or RE) for devices with no VIO pin	-0.3	$V_{CC} + 0.2$	V
Receiver output current	$I_O$	-24	24	mA
Storage temperature	$T_{stg}$	-65	170	°C

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

### 6.2 ESD Ratings

			VALUE	UNIT	
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/ JEDEC JS-001 <sup>(1)</sup>	Bus terminals and GND	±16,000	V
			All pins except bus terminals and GND	±4,000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>		±1,500	V

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 ESD Ratings - IEC Specifications

			VALUE	UNIT	
$V_{(ESD)}$	Electrostatic discharge, bus terminals	Contact discharge, per IEC 61000-4-2 <sup>(1)</sup>	Bus terminals and GND	±8,000	V
		Air-gap discharge, per IEC 61000-4-2 <sup>(1)</sup>	Bus terminals and GND	±15,000	
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20µs CWG (DRC Package)	Bus terminals and GND	±1500	V
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20µs CWG (D Package)	Bus terminals and GND	±3,000	V

- (1) For optimised IEC ESD performance, it is recommended to have series resistor ( $\geq 50 \Omega$ ) on all logic inputs to minimize transient currents going into or out of the logic pins.

## 6.4 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>CC</sub>	Supply voltage	3		5.5	V
V <sub>IO</sub>	I/O supply voltage (devices with VIO pin)	1.65		V <sub>CC</sub>	V
V <sub>IH</sub>	High-level input voltage (D, DE, RE)	0.7		1	V <sub>IO</sub>
V <sub>IL</sub>	Low-level input voltage (D, DE, RE)				
V <sub>IH</sub>	High-level input voltage (D, DE, RE)	0.7		1	V <sub>CC</sub>
V <sub>IL</sub>	Low-level input voltage (D, DE, RE)				
V <sub>I</sub>	Input voltage at any bus terminal (separately or common mode) <sup>(1)</sup>	-25		25	V
V <sub>ID</sub>	Differential input voltage	-25		25	V
I <sub>O</sub>	Output current, driver	-60		60	mA
I <sub>OR</sub>	Output current, receiver	-4		4	mA
I <sub>OR</sub>	Output current, receiver	-8		8	mA
R <sub>L</sub>	Differential load resistance	54	60		Ω
1/t <sub>UI</sub>	Signaling rate	THVD2419		250	kbps
		THVD2429		20	Mbps
T <sub>A</sub>	Operating ambient temperature	-40		125	°C
T <sub>J</sub>	Junction temperature	-40		150	°C

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

## 6.5 Thermal Information

THERMAL METRIC <sup>(1)</sup>		THVD2419, THVD2429		UNIT
		DRC (VSON)	D (SOIC)	
		10 PINS	8 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	65.2	117.2	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	41.7	40.2	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	36.4	65.3	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	1.4	3.3	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	36.3	64.4	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	24.9	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.6 Power Dissipation

PARAMETER		TEST CONDITIONS		VALUE	UNIT	
P <sub>D</sub>	Driver and receiver enabled, V <sub>CC</sub> = 5.5 V, T <sub>A</sub> = 125 °C, square wave at 50% duty cycle	Unterminated R <sub>L</sub> = 300Ω, C <sub>L</sub> = 50pF (driver)	THVD2419	250kbps	180	mW
			THVD2429	20Mbps	310	
		RS-422 load R <sub>L</sub> = 100Ω, C <sub>L</sub> = 50pF (driver)	THVD2419	250kbps	180	mW
			THVD2429	20Mbps	310	
		RS-485 load R <sub>L</sub> = 54Ω, C <sub>L</sub> = 50pF (driver)	THVD2419	250kbps	270	mW
			THVD2429	20Mbps	325	

## 6.7 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of  $V_{CC} = 5V$ ,  $V_{IO} = 3.3V$ , unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Driver</b>						
V <sub>OD</sub>	Driver differential output voltage magnitude	$R_L = 60\Omega, -25V \leq V_{test} \leq 25V$ (See Figure 7-1)	1.5	2.8		V
		$R_L = 60\Omega, -25V \leq V_{test} \leq 25V, 4.5V \leq V_{CC} \leq 5.5V$ (See Figure 7-1)	2.1	3.3		V
		$R_L = 100\Omega$ (See Figure 7-2)	2	2.9		V
		$R_L = 54\Omega$ (See Figure 7-2)	1.5	2.5		V
$\Delta V_{OD} $	Change in differential output voltage	$R_L = 54\Omega$ or $100\Omega$ (See Figure 7-2)	-50		50	mV
V <sub>OC</sub>	Common-mode output voltage		1	$V_{CC}/2$	3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage		-50		50	mV
I <sub>OS</sub>	Short-circuit output current	$DE = V_{IO}, -42V \leq (V_A \text{ or } V_B) \leq 42V$ , or A shorted to B	-250		250	mA
<b>Receiver</b>						
I <sub>I</sub>	Bus input current	$DE = 0V, V_{CC}$ and $V_{IO} = 0V$ or $5.5V$	$V_I = 12V$	90	125	$\mu A$
			$V_I = 25V$	200	250	$\mu A$
			$V_I = -7V$	-100	-80	$\mu A$
			$V_I = -25V$	-350	-240	$\mu A$
V <sub>TH+</sub>	Positive-going input threshold voltage <sup>(1)</sup>	Over common-mode range of $\pm 25V$	20	125	200	mV
V <sub>TH-</sub>	Negative-going input threshold voltage <sup>(1)</sup>		-200	-125	-20	mV
V <sub>HYS</sub>	Input hysteresis		250			mV
V <sub>TH_FSH</sub>	Input fail-safe threshold		-20		20	mV
C <sub>A,B</sub>	Input differential capacitance	Measured between A and B, $f = 1MHz$		50		pF
V <sub>OH</sub>	Output high voltage	$I_{OH} = -8mA, V_{IO} = 3$ to $3.6V$ or $4.5V$ to $5.5V$	$V_{IO} - 0.4$	$V_{IO} - 0.2$		V
V <sub>OL</sub>	Output low voltage	$I_{OL} = 8mA, V_{IO} = 3$ to $3.6V$ or $4.5V$ to $5.5V$		0.2	0.4	V
V <sub>OH</sub>	Output high voltage	$I_{OH} = -4mA, V_{IO} = 1.65$ to $1.95V$ or $2.25V$ to $2.75V$	$V_{IO} - 0.4$	$V_{IO} - 0.2$		V
V <sub>OL</sub>	Output low voltage	$I_{OL} = 4mA, V_{IO} = 1.65$ to $1.95V$ or $2.25V$ to $2.75V$		0.2	0.4	V
I <sub>OZ</sub>	Output high-impedance current, R pin	$V_O = 0V$ or $V_{IO}, \bar{RE} = V_{IO}$	-1		1	$\mu A$
<b>Logic</b>						
I <sub>IN</sub>	Input current (DE, SLR)	DRC: $1.65V \leq V_{IO} \leq 5.5V, 0V \leq V_{IN} \leq V_{IO}$ D: $3V \leq V_{CC} \leq 5.5V, 0V \leq V_{IN} \leq 5.5V$			5	$\mu A$
I <sub>IN</sub>	Input current (D, $\bar{RE}$ )	DRC: $1.65V \leq V_{IO} \leq 5.5V, 0V \leq V_{IN} \leq V_{IO}$ D: $3V \leq V_{CC} \leq 5.5V, 0V \leq V_{IN} \leq 5.5V$	-5			$\mu A$
<b>Thermal Protection</b>						
T <sub>SHDN</sub>	Thermal shutdown threshold	Temperature rising	150	180		°C
T <sub>HYS</sub>	Thermal shutdown hysteresis			10		°C
<b>Supply</b>						
UV <sub>VCC</sub> (rising)	Rising under-voltage threshold on $V_{CC}$			2.3	2.6	V
UV <sub>VCC</sub> (falling)	Falling under-voltage threshold on $V_{CC}$		1.95	2.2		V
UV <sub>VCC(hys)</sub>	Hysteresis on under-voltage of $V_{CC}$			150		mV
UV <sub>VIO</sub> (rising)	Rising under-voltage threshold on $V_{IO}$			1.4	1.6	V
UV <sub>VIO</sub> (falling)	Falling under-voltage threshold on $V_{IO}$		1.2	1.3		V

## 6.7 Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of  $V_{CC} = 5V$ ,  $V_{IO} = 3.3V$ , unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$UV_{VIO(hys)}$	Hysteresis on under-voltage of $V_{IO}$				120		mV
$I_{CC}$	Supply current (quiescent), $V_{CC} = 4.5V$ to $5.5V$	Driver and receiver enabled	$\overline{RE} = 0V$ , $DE = V_{IO}$ , No load		3.5	5.7	mA
		Driver enabled, receiver disabled	$\overline{RE} = V_{IO}$ , $DE = V_{IO}$ , No load		2.5	4.4	mA
		Driver disabled, receiver enabled	$\overline{RE} = 0V$ , $DE = 0V$ , No load		1.8	2.4	mA
		Driver and receiver disabled (devices without VIO pin)	$\overline{RE} = V_{CC}$ , $DE = 0V$ , $D = open$ , No load		1.7	5	$\mu A$
		Driver and receiver disabled (devices with VIO pin)	$\overline{RE} = V_{IO}$ , $DE = 0V$ , $D = open$ , No load		0.1	3	$\mu A$
$I_{CC}$	Supply current (quiescent), $V_{CC} = 3V$ to $3.6V$	Driver and receiver enabled	$\overline{RE} = 0V$ , $DE = V_{IO}$ , No load		3	4.6	mA
		Driver enabled, receiver disabled	$\overline{RE} = V_{IO}$ , $DE = V_{IO}$ , No load		2.2	3.3	mA
		Driver disabled, receiver enabled	$\overline{RE} = 0V$ , $DE = 0V$ , No load		1.6	2.2	mA
		Driver and receiver disabled (Devices without VIO pin)	$\overline{RE} = V_{CC}$ , $DE = 0V$ , $D = open$ , No load		1	4	$\mu A$
		Driver and receiver disabled (Devices with VIO pin)	$\overline{RE} = V_{IO}$ , $DE = 0V$ , $D = open$ , No load		1	2	$\mu A$
$I_{IO}$	Logic supply current (quiescent), $V_{IO} = 3$ to $3.6V$ , Devices with VIO pin	Driver disabled, Receiver enabled	$DE = 0V$ , $\overline{RE} = 0V$ , No load		3.3	8.4	$\mu A$
		Driver disabled, Receiver disabled	$DE = 0V$ , $\overline{RE} = V_{IO}$ , No load		0.1	2	$\mu A$

(1) Under any specific conditions,  $V_{TH+}$  is assured to be at least  $V_{HYS}$  higher than  $V_{TH-}$ .

## 6.8 Switching Characteristics 250kbps

250kbps (THVD2419) over recommended operating conditions. All typical values are at 25°C and supply voltage of  $V_{CC} = 5V$ ,  $V_{IO} = 3.3V$ , unless otherwise noted. <sup>(1)</sup>

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
<b>Driver</b>								
$t_r, t_f$	Differential output rise/fall time	$R_L = 54 \Omega$ , $C_L = 50 \text{ pF}$ See <a href="#">Figure 7-3</a>	$V_{CC} = 3 \text{ to } 3.6V$ , Typical at 3.3V	400	625	1200	ns	
			$V_{CC} = 4.5 \text{ to } 5.5V$ , Typical at 5V	500	725	1200	ns	
$t_{PHL}, t_{PLH}$	Propagation delay	$R_L = 54 \Omega$ , $C_L = 50 \text{ pF}$ See <a href="#">Figure 7-3</a>			510	750	ns	
$t_{SK(P)}$	Pulse skew, $ t_{PHL} - t_{PLH} $				5	70	ns	
$t_{PHZ}, t_{PLZ}$	Disable time	See <a href="#">Figure 7-4</a> and <a href="#">Figure 7-5</a>	$\overline{RE} = X$		45	75	ns	
$t_{PZH}, t_{PZL}$	Enable time		$\overline{RE} = 0V$		80	290	ns	
			$\overline{RE} = V_{IO}$		2.5	4.5	$\mu\text{s}$	
$t_{SHDN}$	Time to shutdown		$\overline{RE} = V_{IO}$	50		500	ns	
<b>Receiver</b>								
$t_r, t_f$	Output rise/fall time	$C_L = 15 \text{ pF}$ See <a href="#">Figure 7-6</a>			3	20	ns	
$t_{PHL}, t_{PLH}$	Propagation delay				750	1270	ns	
$t_{SK(P)}$	Pulse skew, $ t_{PHL} - t_{PLH} $				5	45	ns	
$t_{PHZ}, t_{PLZ}$	Disable time	DE = X			30	40	ns	
$t_{PZH(1)}$	Enable time				80	130	ns	
$t_{PZL(1)}$	Enable time	See <a href="#">Figure 7-7</a>			800	1320	ns	
$t_{PZH(2)}, t_{PZL(2)}$	Enable time	See <a href="#">Figure 7-8</a>	DE = 0V		3	5.4	$\mu\text{s}$	
$t_{D(OFS)}$	Delay to enter fail-safe operation	See <a href="#">Figure 7-9</a>	$C_L = 15\text{pF}$		7	11	18	$\mu\text{s}$
$t_{D(FSO)}$	Delay to exit fail-safe operation				540	750	1260	ns
$t_{SHDN}$	Time to shutdown	See <a href="#">Figure 7-8</a>	DE = 0V	50		500	ns	

(1) A, B are driver output and receiver input terminals for Half duplex devices. A, B are RX input, Y/Z are driver output terminals for Full duplex device

## 6.9 Switching Characteristics 20Mbps

20Mbps (THVD2429) over recommended operating conditions. All typical values are at 25°C and supply voltage of  $V_{CC} = 5V$ ,  $V_{IO} = 3.3V$ , unless otherwise noted. <sup>(1)</sup>

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
<b>Driver</b>								
$t_r, t_f$	Differential output rise/fall time	$R_L = 54\Omega$ , $C_L = 50\text{pF}$ See <a href="#">Figure 7-3</a>		3.5	5	15	ns	
$t_{PHL}, t_{PLH}$	Propagation delay	$R_L = 54\Omega$ , $C_L = 50\text{pF}$ See <a href="#">Figure 7-3</a>		6	15	30	ns	
$t_{SK(P)}$	Pulse skew, $ t_{PHL} - t_{PLH} $	$R_L = 54\Omega$ , $C_L = 50\text{pF}$ See <a href="#">Figure 7-3</a>			0.5	3	ns	
$t_{PHZ}, t_{PLZ}$	Disable time	See <a href="#">Figure 7-4</a> and <a href="#">Figure 7-5</a>	$\overline{RE} = X$		20	35	ns	
$t_{PZH}, t_{PZL}$	Enable time		$\overline{RE} = 0V$		16	40	ns	
			$\overline{RE} = V_{IO}$		2.5	4.5	$\mu\text{s}$	
$t_{SHDN}$	Time to shutdown		$\overline{RE} = V_{IO}$	50		500	ns	
<b>Receiver</b>								
$t_r, t_f$	Output rise/fall time	$C_L = 15\text{pF}$ , See <a href="#">Figure 7-6</a>			1.5	6	ns	
$t_{PHL}, t_{PLH}$	Propagation delay				25	35	60	ns
$t_{SK(P)}$	Pulse skew, $ t_{PHL} - t_{PLH} $					5.5	ns	
$t_{PHZ}, t_{PLZ}$	Disable time	DE = X			18	25	ns	
$t_{PZH(1)}, t_{PZL(1)}$	Enable time	See <a href="#">Figure 7-7</a>	DE = $V_{IO}$		55	82	ns	



## 6.9 Switching Characteristics 20Mbps (continued)

20Mbps (THVD2429) over recommended operating conditions. All typical values are at 25°C and supply voltage of  $V_{CC} = 5$  V,  $V_{IO} = 3.3$  V, unless otherwise noted. <sup>(1)</sup>

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{PZH(2)}$ , $t_{PZL(2)}$	Enable time	See <a href="#">Figure 7-8</a>	DE = 0V		2.5	4.5	μs
$t_{D(OFS)}$	Delay to enter fail-safe operation	See <a href="#">Figure 7-9</a>	$C_L = 15$ pF	7	10	18	μs
$t_{D(FSO)}$	Delay to exit fail-safe operation			19	35	50	ns
$t_{SHDN}$	Time to shutdown	See <a href="#">Figure 7-8</a>	DE = 0V	50		500	ns

- (1) A, B are driver output and receiver input terminals for Half duplex devices. A, B are RX input, Y/Z are driver output terminals for Full duplex device

### 6.10 Typical Characteristics

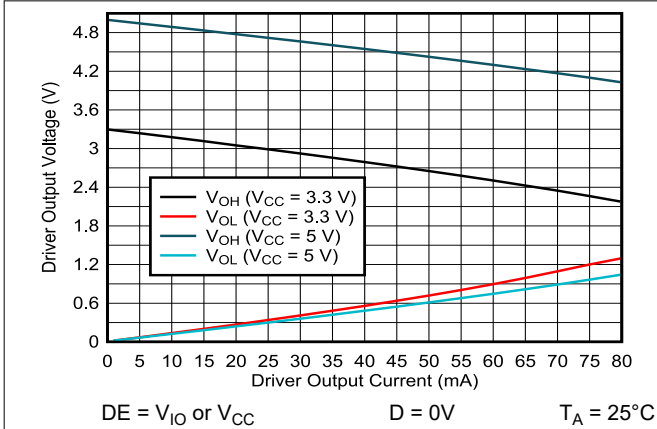


Figure 6-1. Driver Output Voltage vs Driver Output Current

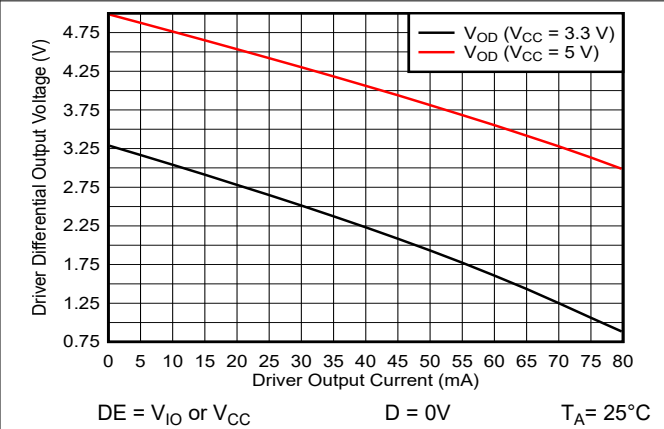


Figure 6-2. Driver Differential Output Voltage vs Driver Output Current

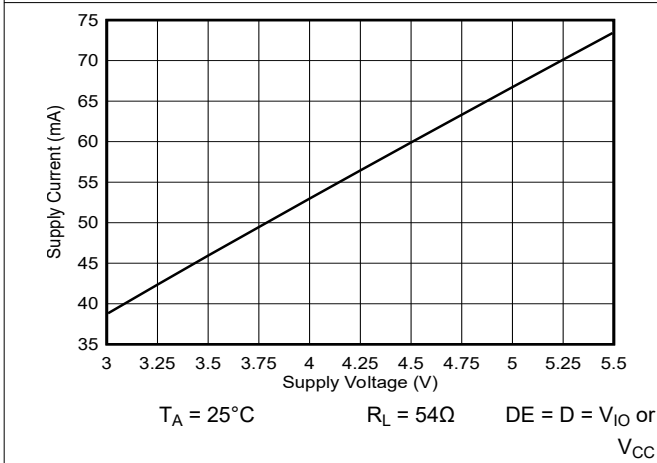


Figure 6-3. Driver Output Current vs Supply Voltage

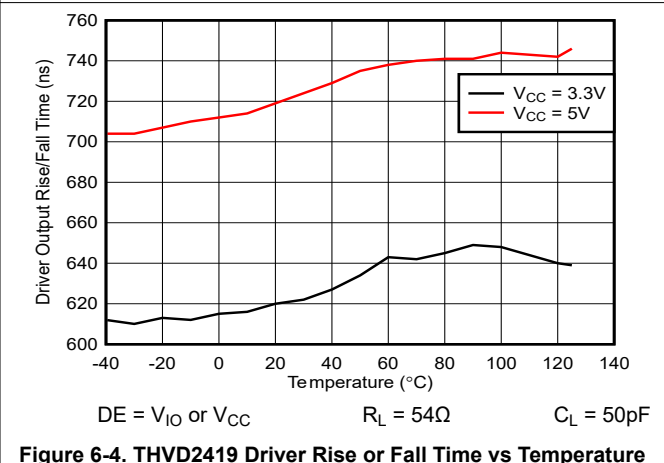


Figure 6-4. THVD2419 Driver Rise or Fall Time vs Temperature

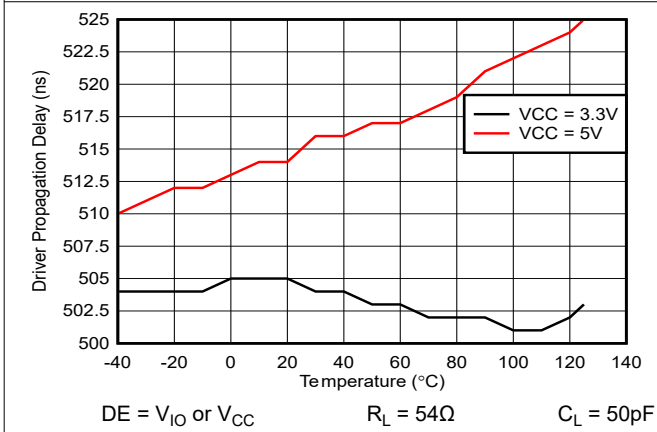


Figure 6-5. THVD2419 Driver Propagation Delay vs Temperature

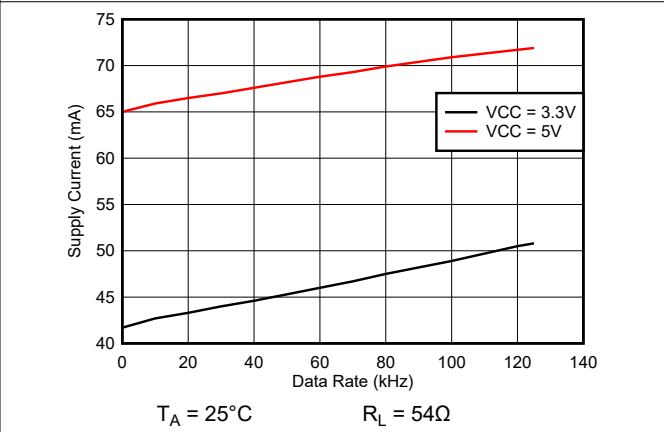


Figure 6-6. THVD2419 Supply Current vs Signal Rate

### 6.10 Typical Characteristics (continued)

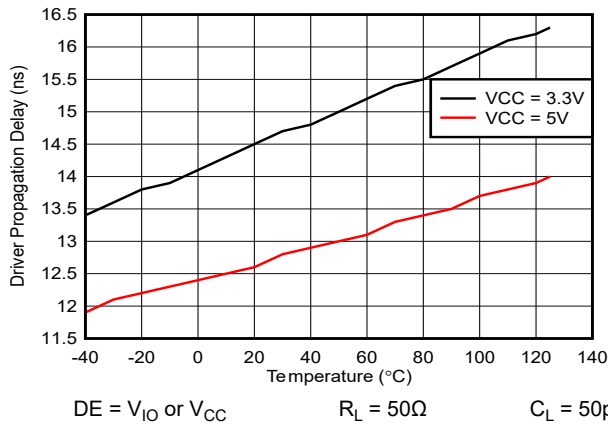


Figure 6-7. THVD2429 Driver Propagation Delay vs Temperature

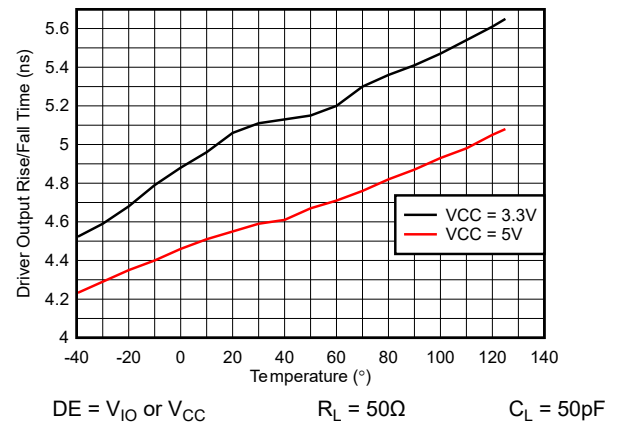


Figure 6-8. THVD2429 Driver Rise or Fall Time vs Temperature

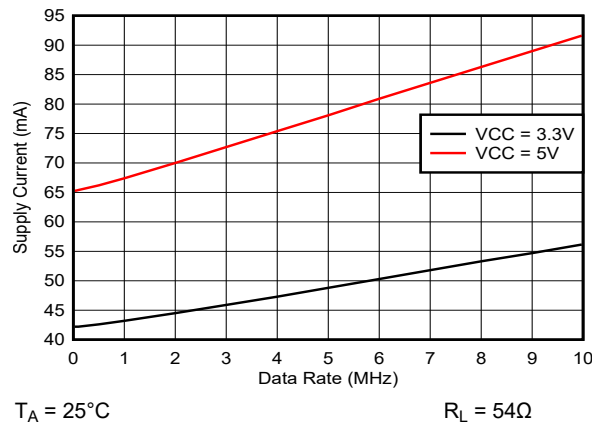


Figure 6-9. THVD2429 Supply Current vs Signal Rate

## 7 Parameter Measurement Information

### Note

Note: Digital input/output supply in the diagrams below could either be  $V_{CC}$  (devices without  $V_{IO}$  pin) or  $V_{IO}$  (devices with  $V_{IO}$  pin)

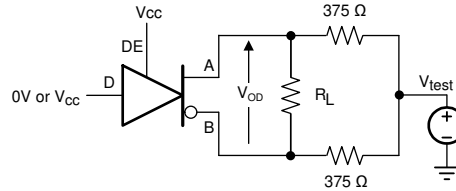


Figure 7-1. Measurement of Driver Differential Output Voltage With Common-Mode Load



Figure 7-2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

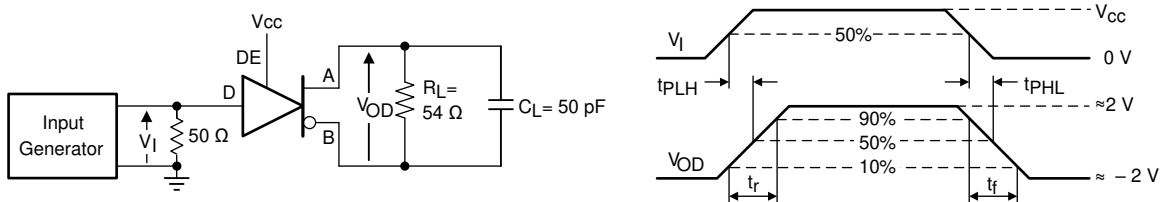


Figure 7-3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

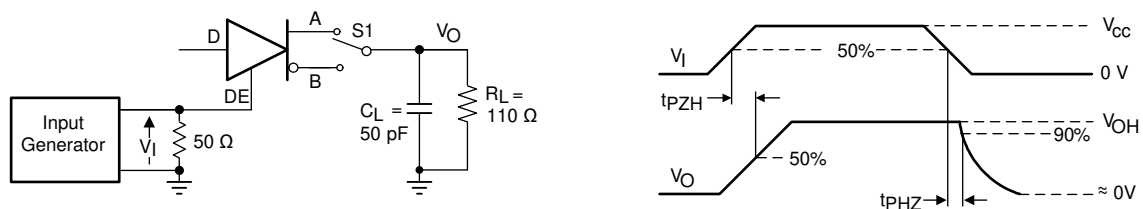


Figure 7-4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

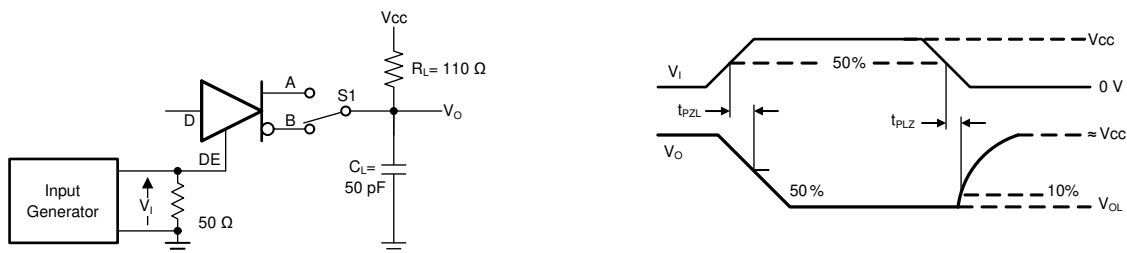


Figure 7-5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

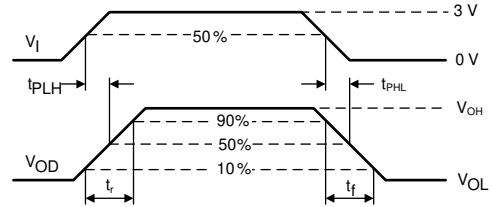
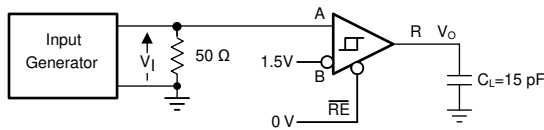


Figure 7-6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

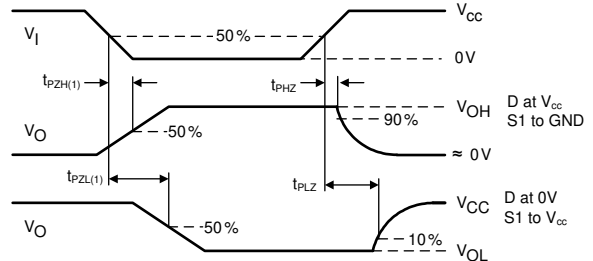
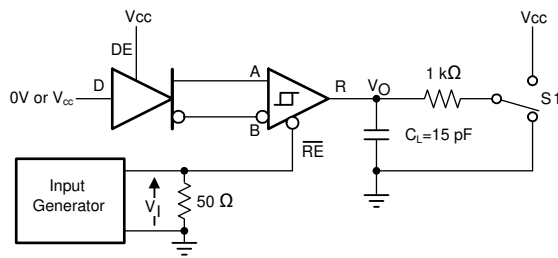


Figure 7-7. Measurement of Receiver Enable/Disable Times With Driver Enabled

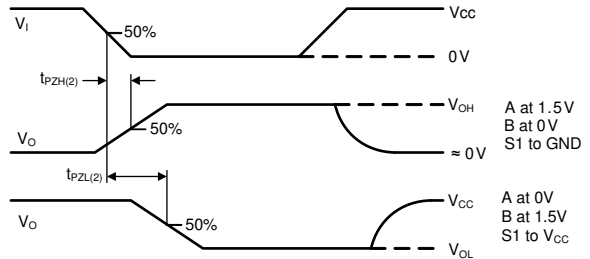
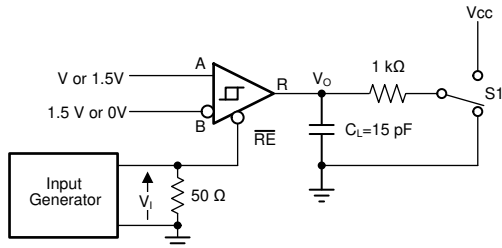
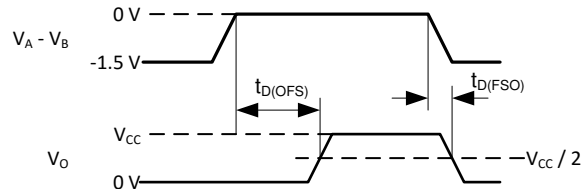
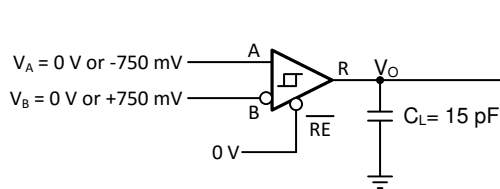


Figure 7-8. Measurement of Receiver Enable Times With Driver Disabled



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Figure 7-9. Fail-Safe Delay Measurements

## 8 Detailed Description

### 8.1 Overview

THVD24x9 devices are surge-protected, half duplex RS-485 transceivers available in two speed grades suitable for data transmission up to 250kbps and 20Mbps respectively. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package and a small 10-pin leadless package.

THVD2419 and THVD2429 devices have active-high driver enables and active-low receiver enables. A low standby current can be achieved by disabling both driver and receiver.

### 8.2 Functional Block Diagrams

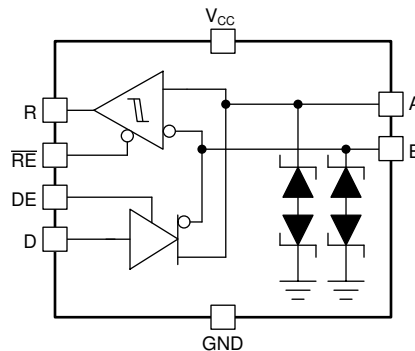


Figure 8-1. THVD2419 and THVD2429 Block Diagram (SOIC Package)

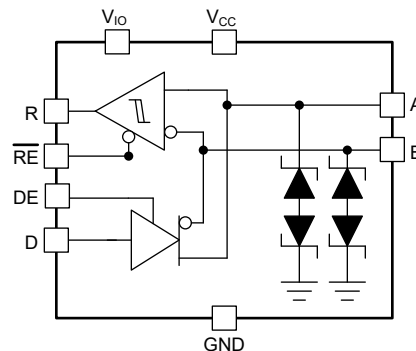


Figure 8-2. THVD2419 and THVD2429 Block Diagram (VSON Package)

### 8.3 Feature Description

#### 8.3.1 Electrostatic Discharge (ESD) Protection

The bus pins of the THVD24x9 transceiver family include on-chip ESD protection against  $\pm 15\text{kV}$  HBM and  $\pm 8\text{kV}$  IEC 61000-4-2 contact discharge. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance,  $C_{(S)}$ , and 78% lower discharge resistance,  $R_{(D)}$ , of the IEC model produce significantly higher discharge currents than the HBM model. As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method.

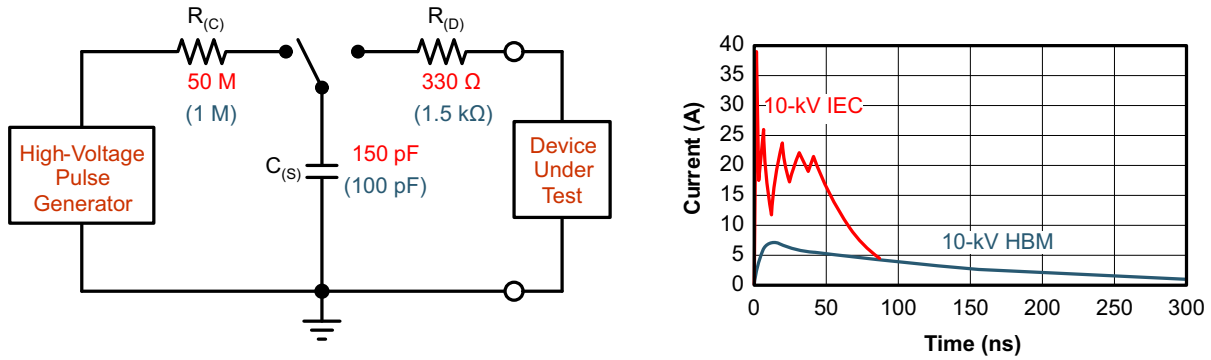


Figure 8-3. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

The on-chip implementation of IEC ESD protection significantly increases the robustness of equipment. Common discharge events occur because of human contact with connectors and cables.

### 8.3.2 Electrical Fast Transient (EFT) Protection

Inductive loads such as relays, switch contactors, or heavy-duty motors can create high-frequency bursts during transition. The IEC 61000-4-4 test is intended to simulate the transients created by such switching of inductive loads on AC power lines. Figure 8-4 shows the voltage waveforms in to 50Ω termination as defined by the IEC standard.

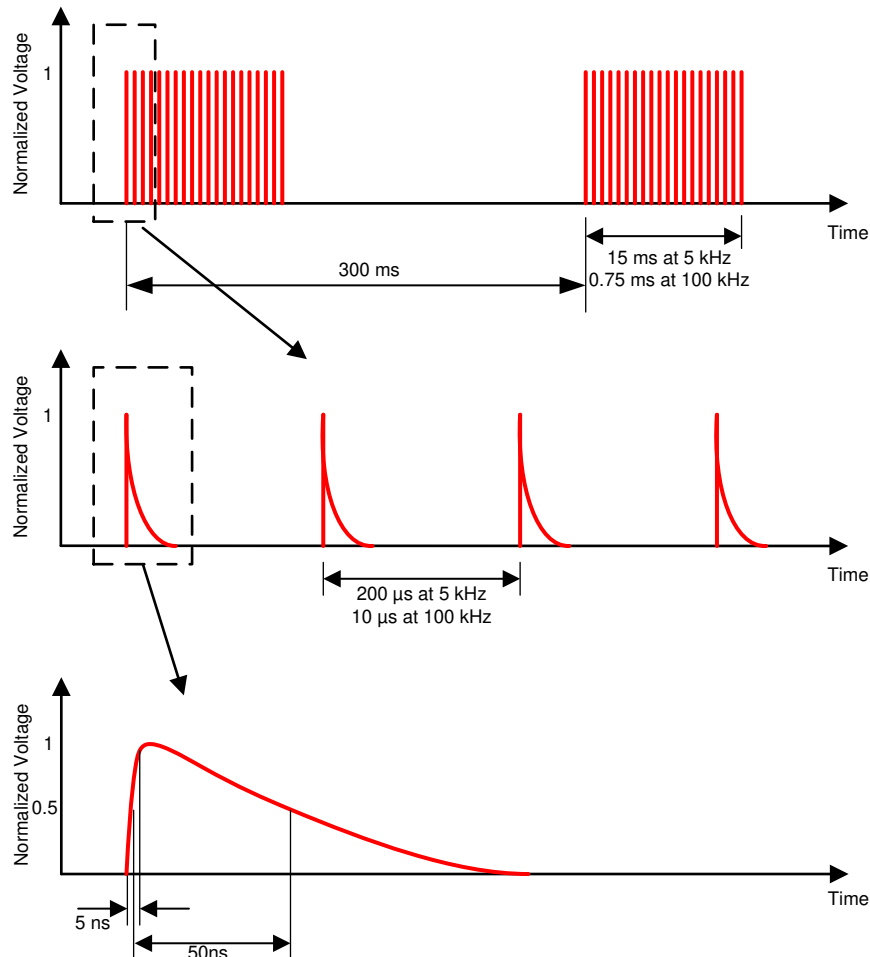


Figure 8-4. EFT Voltage Waveforms

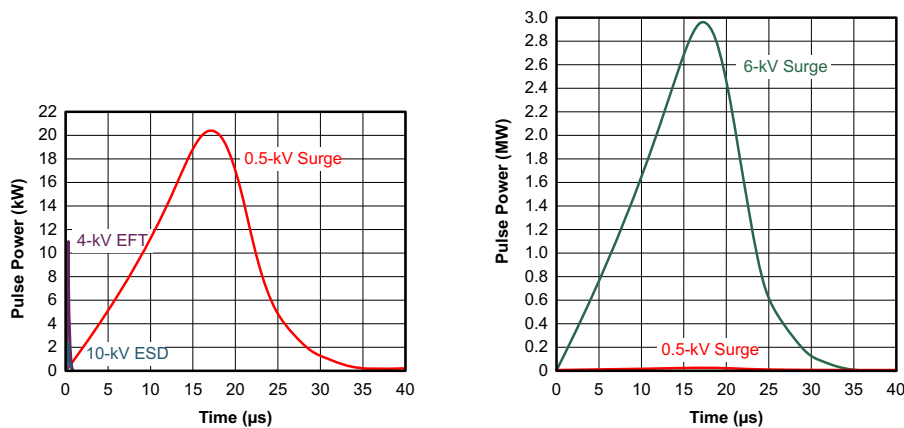
Internal ESD protection circuits of the THVD24x9 protect the transceivers against  $\pm 4\text{kV}$  EFT. With careful system design, one could achieve EFT Criterion A (no data loss when transient noise is present).

### 8.3.3 Surge Protection

Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuit switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems.

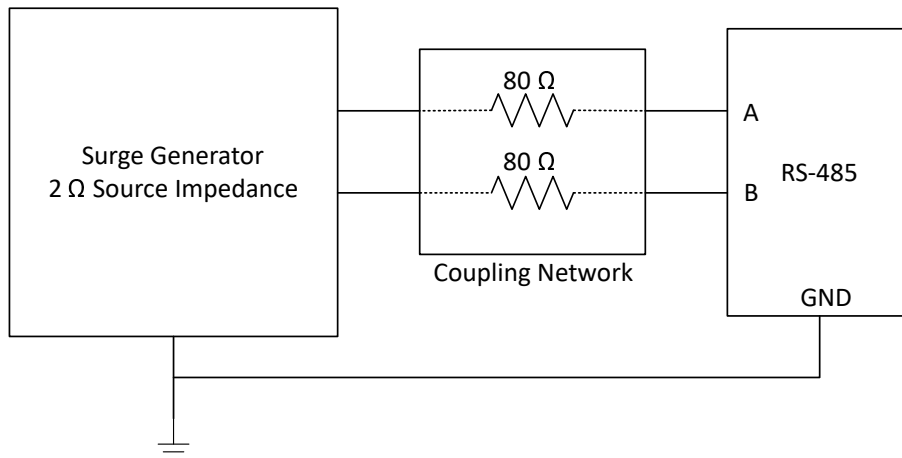
Figure 8-5 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The diagram on the left shows the relative pulse-power for a 0.5kV surge transient and 4kV EFT transient, both of which dwarf the 10kV ESD transient visible in the lower-left corner. 500V surge transients are representative of events that may occur in factory environments in industrial and process automation.

The diagram on the right shows the pulse-power of a 6kV surge transient, relative to the same 0.5kV surge transient. 6kV surge transients are most likely to occur in power generation and power-grid systems.



**Figure 8-5. Power Comparison of ESD, EFT, and Surge Transients**

Figure 8-6 shows the test setup used to validate THVD24x9 surge performance according to the IEC 61000-4-5 1.2/50μs surge pulse.



**Figure 8-6. THVD24x9 Surge Test Setup**

THVD24x9 product family is robust up to  $\pm 3\text{kV}$  surge transients without the need for any external components. The bus pin voltage is clamped by the integrated surge protection diodes such that the internal circuitry is not damaged during the surge event.



### **8.3.4 Enhanced Receiver Noise Immunity**

The differential receivers of THVD24x9 family feature fully symmetric thresholds to maintain duty cycle of the signal even with small input amplitudes. In addition, 250mV (typical) hysteresis displays excellent noise immunity.

### **8.3.5 Failsafe Receiver**

The differential receivers of the THVD24x9 family are failsafe to invalid bus states caused by the following:

- Open bus conditions, such as a disconnected connector
- Shorted bus conditions, such as cable damage shorting the twisted-pair together
- Idle bus conditions that occur when no driver on the bus is actively driving

In any of these cases, the receiver outputs a fail-safe logic high state if the input amplitude stays for longer than  $t_{D(OFS)}$  at less than  $|V_{TH\_FSH}|$ .

## 8.4 Device Functional Modes

When the driver enable pin, DE, is logic high, the differential outputs A and B follow the logic states at data input D. A logic high at D causes A to turn high and B to turn low. The differential output voltage defined as  $V_{OD} = V_A - V_B$  is positive. When D is low, the output states reverse: B turns high, A becomes low, and  $V_{OD}$  is negative.

When DE is low, both outputs turn high-impedance. In this condition the logic state at D is irrelevant. The DE pin has an internal pull-down resistor to ground. When left open the driver is disabled (high-impedance) by default. The D pin has an internal pull-up resistor to  $V_{CC}$ ; thus, when left open while the driver is enabled, output A turns high and B turns low.

**Table 8-1. Driver Function Table**

INPUT	ENABLE	OUTPUTS		FUNCTION
		A	B	
H	H	H	L	Actively drive bus high
L	H	L	H	Actively drive bus low
X	L	Z	Z	Driver disabled
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Actively drive bus high by default

When the receiver enable pin,  $\overline{RE}$ , is logic low, the receiver is enabled. When the differential input voltage defined as  $V_{ID} = V_A - V_B$  is higher than the positive input threshold,  $V_{TH+}$ , the receiver output, R, turns high. When  $V_{ID}$  is lower than the negative input threshold,  $V_{TH-}$ , the receiver output, R, turns low. If  $V_{ID}$  is between  $V_{TH+}$  and  $V_{TH-}$  the output is indeterminate.

When  $\overline{RE}$  is logic high or left open, the receiver output is high-impedance and the magnitude and polarity of  $V_{ID}$  are irrelevant. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), the bus lines are shorted to one another (short-circuit), or the bus is not actively driven (idle bus).

**Table 8-2. Receiver Function Table**

DIFFERENTIAL INPUT	ENABLE	OUTPUT	FUNCTION
$V_{ID} = V_A - V_B$	$\overline{RE}$	R	
$V_{TH+} < V_{ID}$	L	H	Receive valid bus high
$V_{TH-} < V_{ID} < V_{TH+}$	L	Indeterminate	Indeterminate bus state
$V_{ID} < V_{TH-}$	L	L	Receive valid bus low
X	H	Z	Receiver disabled
X	OPEN	Z	Receiver disabled by default
Open-circuit bus	L	H	Fail-safe high output
Short-circuit bus	L	H	Fail-safe high output
Idle (terminated) bus	L	H	Fail-safe high output

## 9 Application and Implementation

### Note

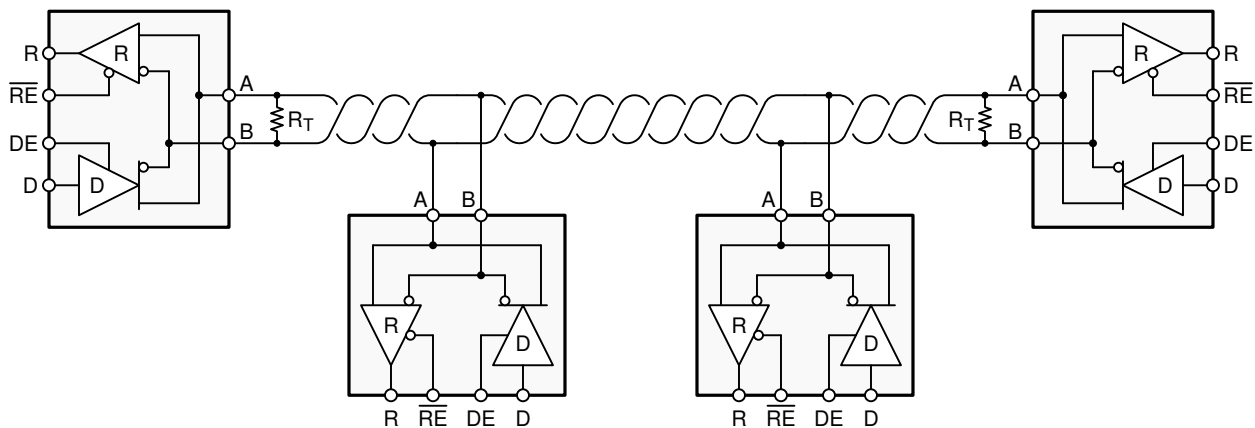
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 9.1 Application Information

THVD24x9 are half-duplex RS-485 transceivers with integrated system-level surge protection. Standard 8-pin SOIC (D) package allows drop-in replacement into existing systems and eliminate system-level protection components.

### 9.2 Typical Application

An RS-485 bus consists of multiple transceivers connecting in parallel to a bus cable. To eliminate line reflections, each cable end is terminated with a termination resistor,  $R_T$ , with a value that matches the characteristic impedance,  $Z_0$ , of the cable. This method, known as parallel termination, allows for higher data rates over longer cable length.



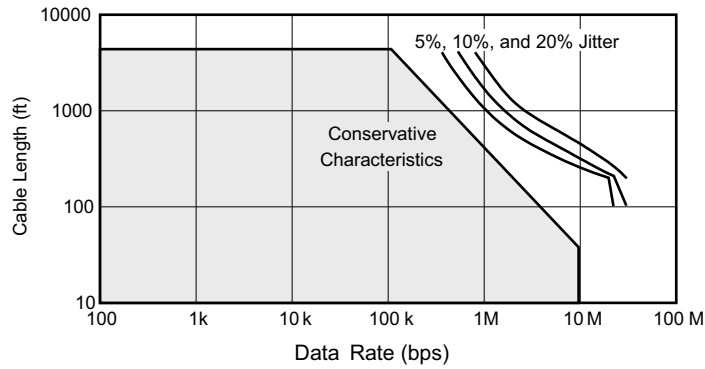
**Figure 9-1. Typical RS-485 Network With Half-Duplex Transceivers**

#### 9.2.1 Design Requirements

RS-485 is a robust electrical standard suitable for long-distance networking that may be used in a wide range of applications with varying requirements, such as distance, data rate, and number of nodes.

##### 9.2.1.1 Data Rate and Bus Length

There is an inverse relationship between data rate and cable length, which means the higher the data rate, the shorter the cable length; and conversely, the lower the data rate, the longer the cable length. While most RS-485 systems use data rates between 10kbps and 100kbps, some applications require data rates up to 250kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.



**Figure 9-2. Cable Length vs Data Rate Characteristic**

Even higher data rates are achievable (that is, 20Mbps for the THVD2429) in cases where the interconnect is short enough (or has suitably low attenuation at signal frequencies) to not degrade the data.

**9.2.1.2 Stub Length**

When connecting a node to the bus, the distance between the transceiver inputs and the cable trunk, known as the stub, should be as short as possible. Stubs present a non-terminated piece of bus line which can introduce reflections as the length of the stub increases. As a general guideline, the electrical length, or round-trip delay, of a stub should be less than one-tenth of the rise time of the driver, thus giving a maximum physical stub length as shown in Equation 1.

$$L_{(STUB)} \leq 0.1 \times t_r \times v \times c \tag{1}$$

where

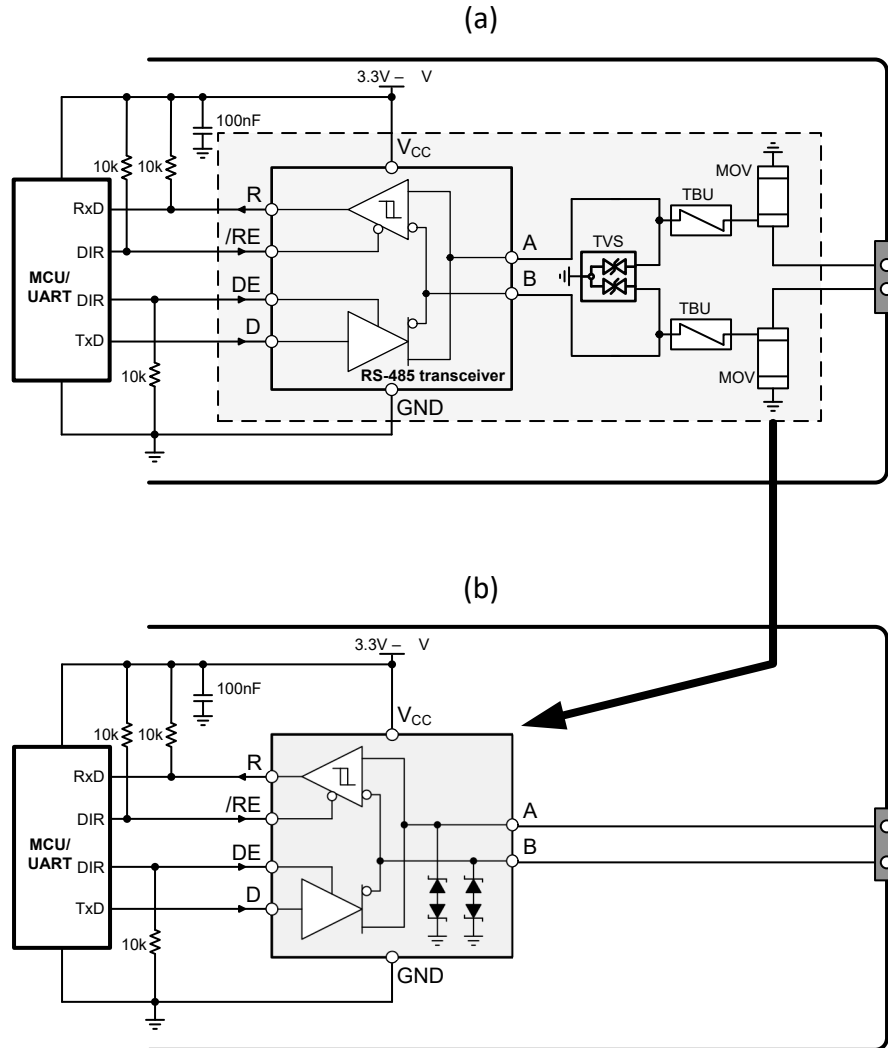
- $t_r$  is the 10/90 rise time of the driver
- $c$  is the speed of light ( $3 \times 10^8$  m/s)
- $v$  is the signal velocity of the cable or trace as a factor of  $c$

**9.2.1.3 Bus Loading**

The RS-485 standard specifies that a compliant driver must be able to driver 32 unit loads (UL), where 1 unit load represents a load impedance of approximately 12kΩ. Because the THVD24x9 devices consist of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible.

### 9.2.2 Detailed Design Procedure

RS-485 transceivers operate in noisy industrial environments typically require surge protection at the bus pins. [Figure 9-3](#) compares the surge protection implementation with a regular RS-485 transceiver (a), against that with a surge-integrated RS-485 transceiver (b), such as the THVD24x9 family. The internal TVS protection of the THVD24x9 achieves up to  $\pm 3\text{kV}$  IEC 61000-4-5 surge protection (SOIC package) without any additional external components, reducing system level bill of materials.



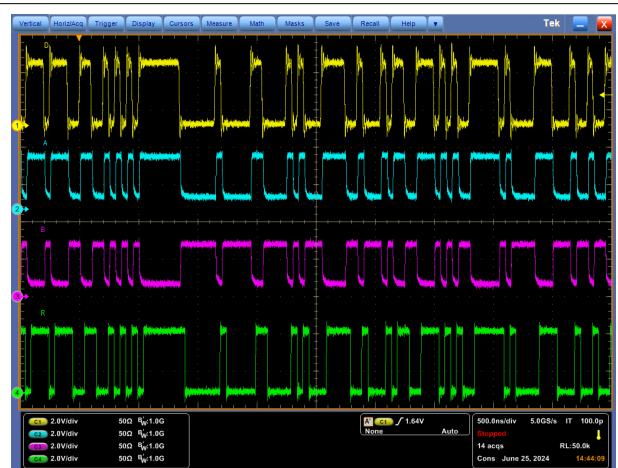
**Figure 9-3. Implementation of System-Level Surge Protection Using THVD24x9**

### 9.2.3 Application Curves



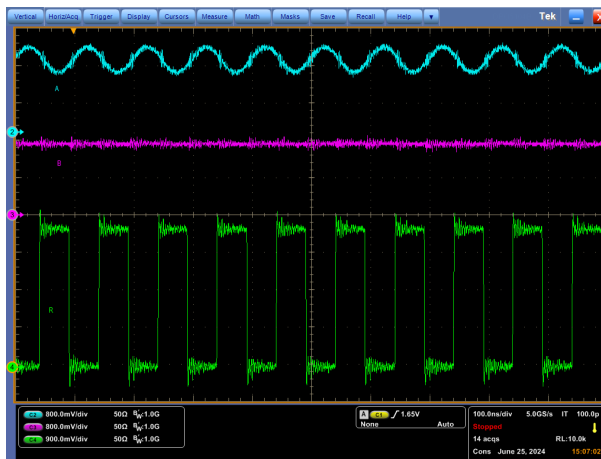
Ch 1: D Input, Ch2: V<sub>A</sub> Ch3: V<sub>B</sub> Ch4: R V<sub>CC</sub> = 3.3V  
 Output Data rate: 20Mbps

**Figure 9-4. THVD2419 Waveforms with 54Ω Termination and V<sub>CC</sub> = 3.3V**



Ch 1: D Input, Ch2: V<sub>A</sub> Ch3: V<sub>B</sub> Ch4: R V<sub>CC</sub> = 3.3V  
 Output Data rate: 20Mbps

**Figure 9-5. THVD2429 Waveforms with 54Ω Termination and V<sub>CC</sub> = 3.3V**



Ch 2: Input A (±200mV sine input over 1.5V DC offset)  
 Ch3: Input B (1.5V)  
 Ch 4: Output R

**Figure 9-6. THVD2429 Receiver Waveform with ±200mV V<sub>ID</sub>**

### 9.3 Power Supply Recommendations

For reliable operation at all data rates and supply voltages, each supply should be decoupled with a 100nF ceramic capacitor located as close to the supply pins as possible. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes.

## 9.4 Layout

### 9.4.1 Layout Guidelines

Additional external protection components generally are not needed when using THVD24x9 transceivers.

1. Use  $V_{CC}/V_{IO}$  and ground planes to provide low-inductance. Note that high-frequency currents tend to follow the path of least impedance and not the path of least resistance. Apply 100nF to 220nF decoupling capacitors as close as possible to the  $V_{CC}/V_{IO}$  pins of transceiver, UART and/or controller ICs on the board.
2. Use at least two vias for  $V_{CC}/V_{IO}$  and ground connections of decoupling capacitors to minimize effective via inductance.
3. Use 1k $\Omega$  to 10k $\Omega$  pull-up and pull-down resistors for enable lines to limit noise currents in these lines during transient events.

### 9.4.2 Layout Example

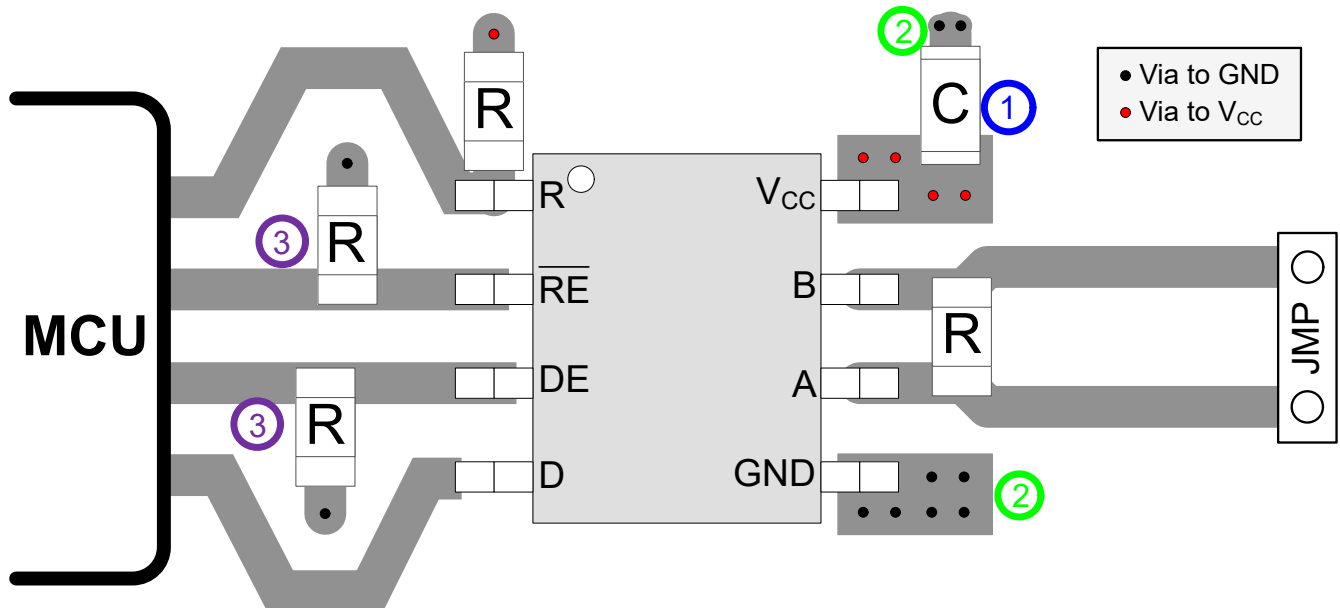


Figure 9-7. THVD2419, THVD2429 Layout Example (SOIC Package)

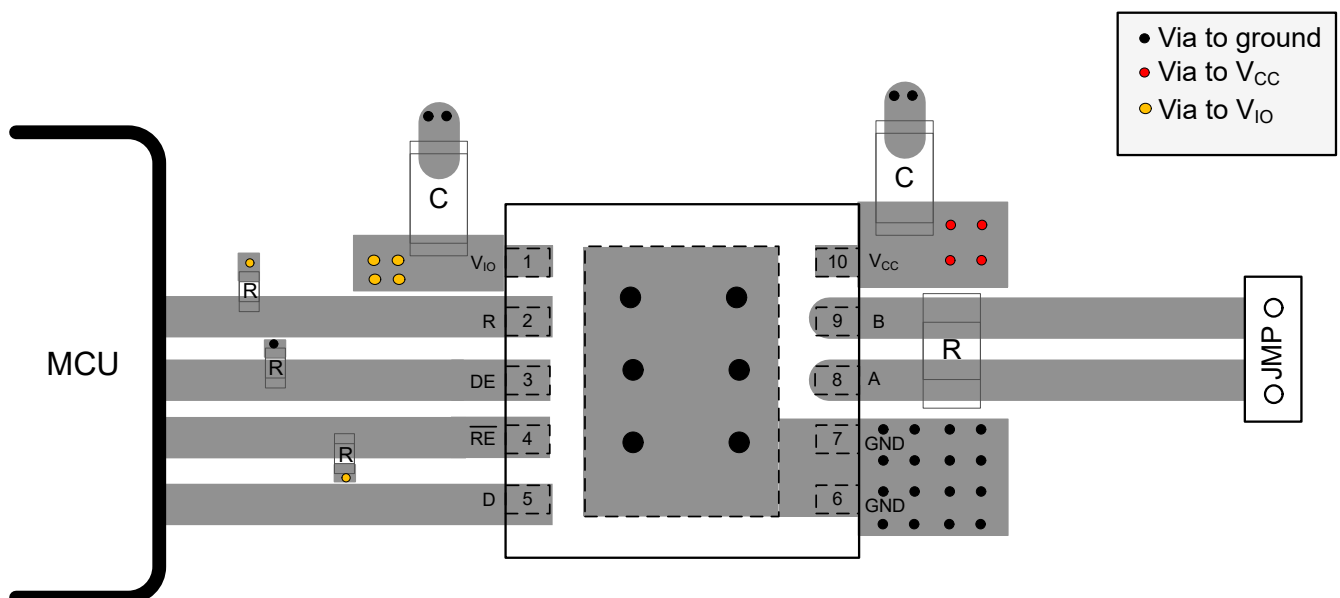


Figure 9-8. THVD2419, THVD2429 Layout Example (VSON Package)

## 10 Device and Documentation Support

### 10.1 Device Support

### 10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 10.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 10.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

### 10.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 10.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (January 2024) to Revision A (August 2024)	Page
• Changed the document from <i>Advanced Information</i> to <i>Production</i> data.....	1

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.



**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">THVD2419DR</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2419 D2419
THVD2419DR.A	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2419 D2419
<a href="#">THVD2419DRCR</a>	Active	Production	VSON (DRC)   10	5000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2419
THVD2419DRCR.A	Active	Production	VSON (DRC)   10	5000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2419
<a href="#">THVD2429DR</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2429 D2429
THVD2429DR.A	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2429 D2429
<a href="#">THVD2429DRCR</a>	Active	Production	VSON (DRC)   10	5000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2429
THVD2429DRCR.A	Active	Production	VSON (DRC)   10	5000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2429

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
THVD2419DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
THVD2419DRCR	VSON	DRC	10	5000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
THVD2429DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
THVD2429DRCR	VSON	DRC	10	5000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THVD2419DR	SOIC	D	8	2500	353.0	353.0	32.0
THVD2419DRCR	VSON	DRC	10	5000	367.0	367.0	35.0
THVD2429DR	SOIC	D	8	2500	353.0	353.0	32.0
THVD2429DRCR	VSON	DRC	10	5000	367.0	367.0	35.0

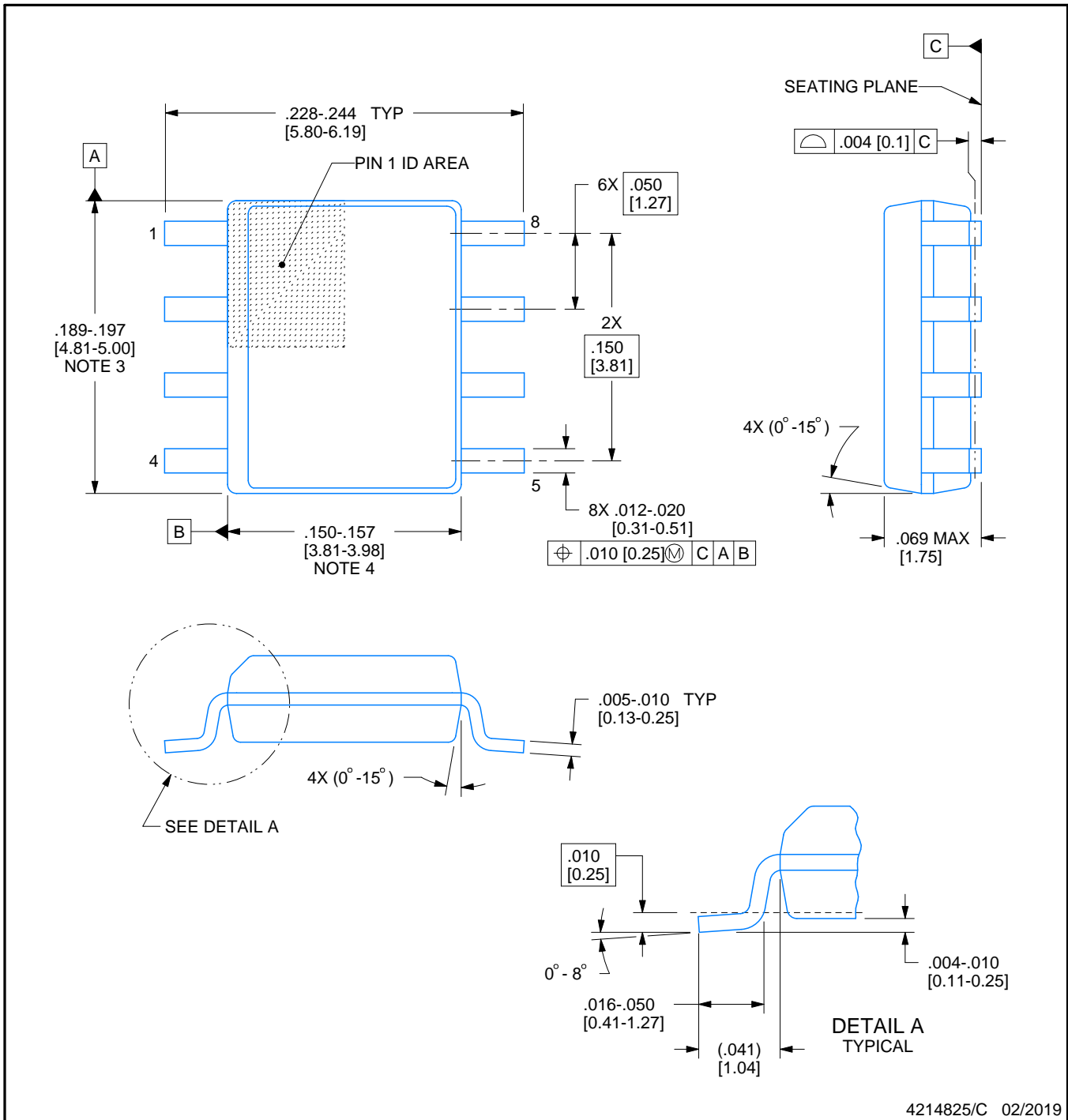


D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
 EXPOSED METAL SHOWN  
 SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## GENERIC PACKAGE VIEW

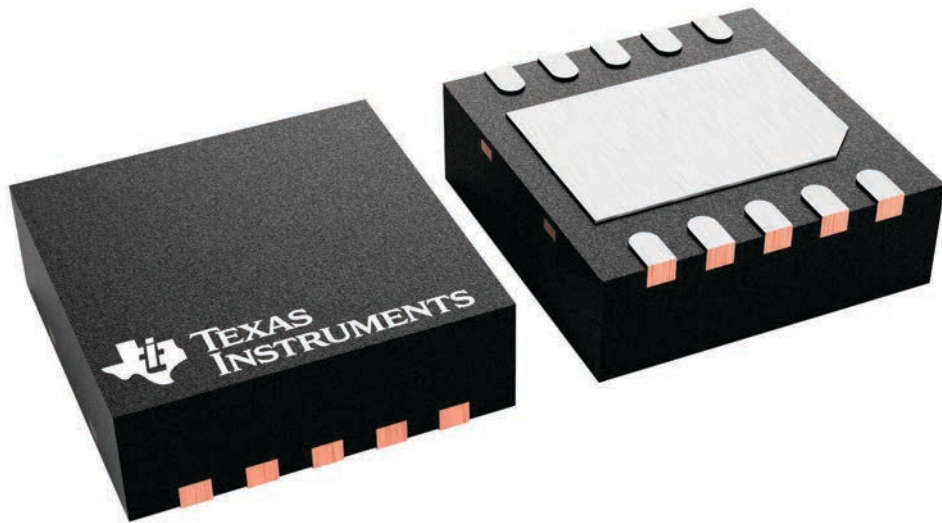
**DRC 10**

**VSON - 1 mm max height**

3 x 3, 0.5 mm pitch

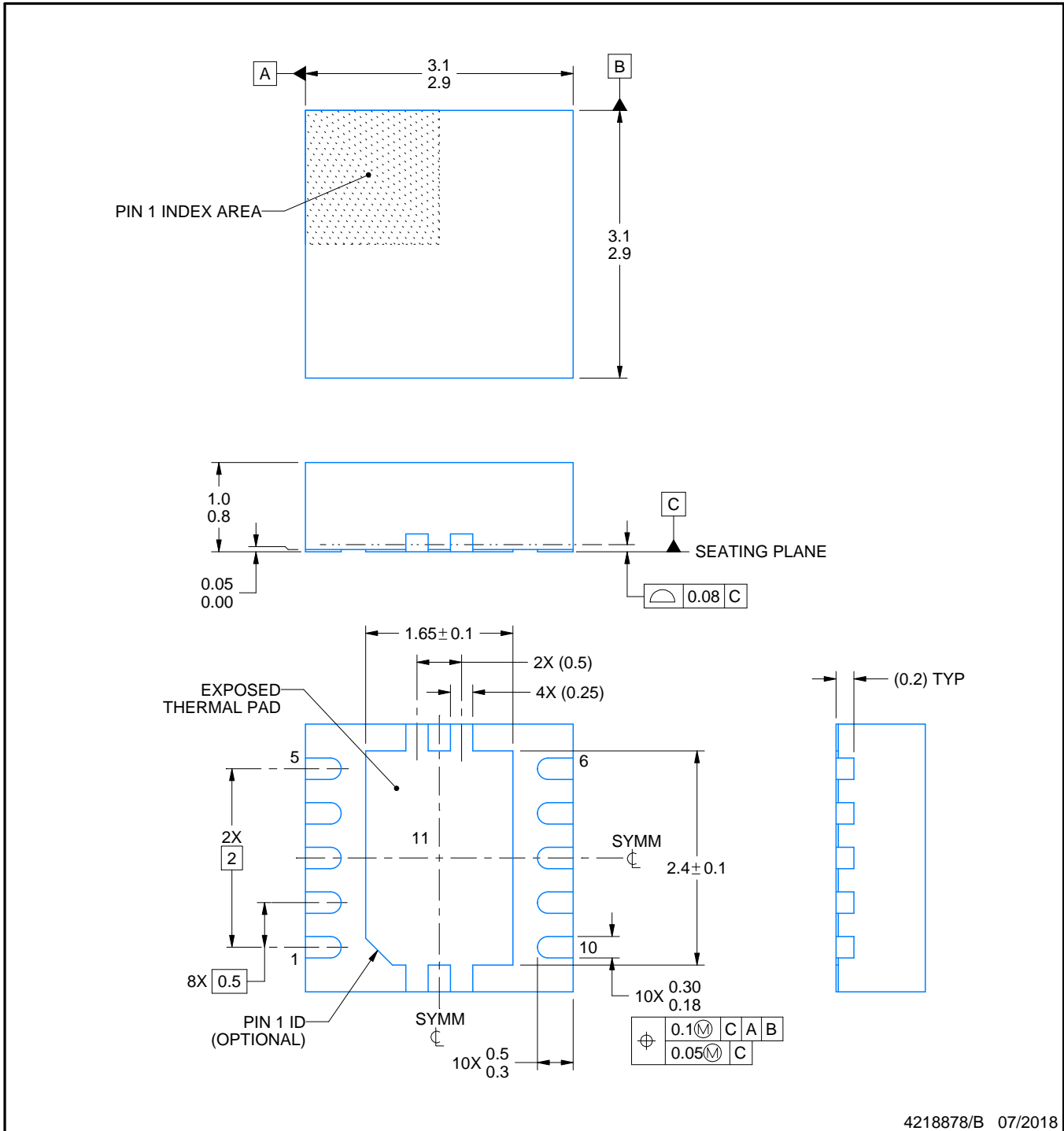
PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4226193/A





4218878/B 07/2018

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

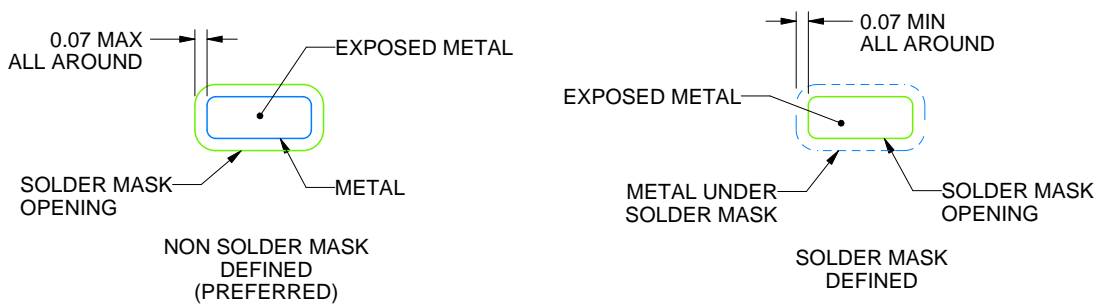
DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



SOLDER MASK DETAILS

4218878/B 07/2018

NOTES: (continued)

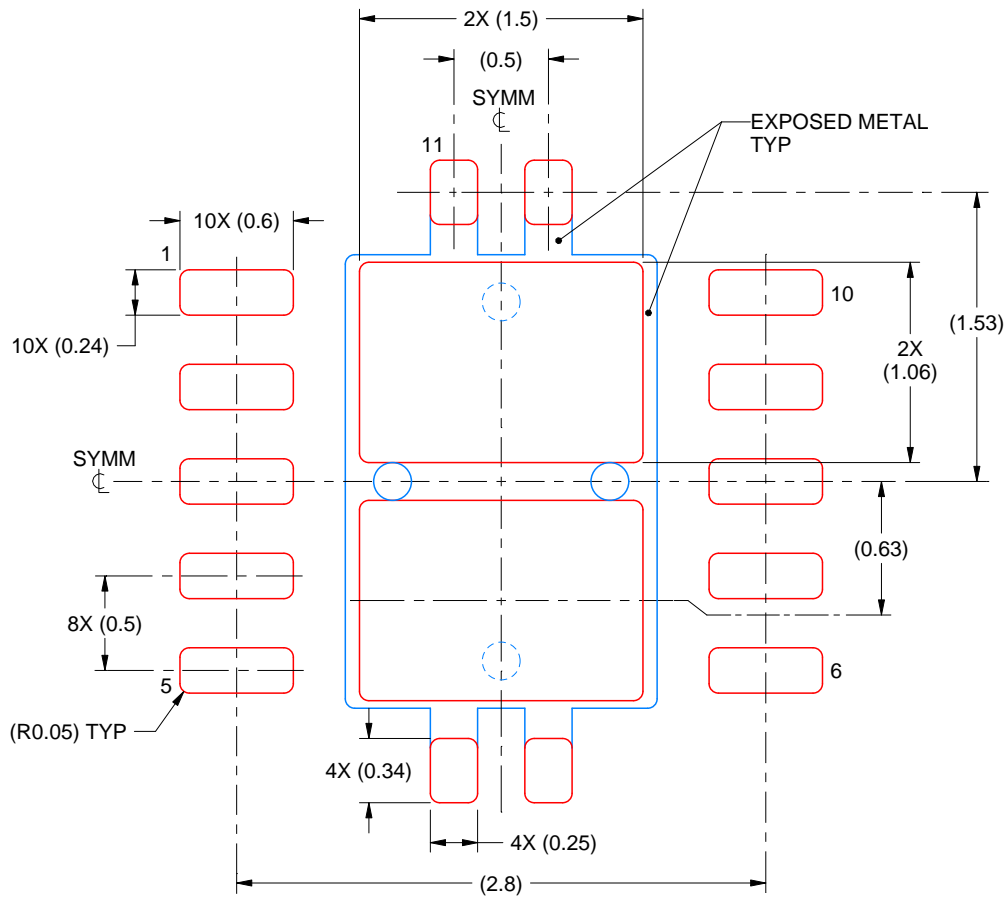
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 11:  
80% PRINTED SOLDER COVERAGE BY AREA  
SCALE:25X

4218878/B 07/2018

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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